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TRENDS IN A SAMPLE OF DEFENSE AIRCRAFT CONTRACTORS' COSTS

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August 1990

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This paper contains information on historical trends in direct and indirect costs for four defense aircraft contractors: General Dynamics-Fort Worth Division, Grumman Aerospace Corporation, McDonnell Aircraft Company, and Northrop Aircraft Company. The trends are presented for those four contractors in aggregate rather than individually. The paper concludes with a look at what these trends may mean in terms of future costs.

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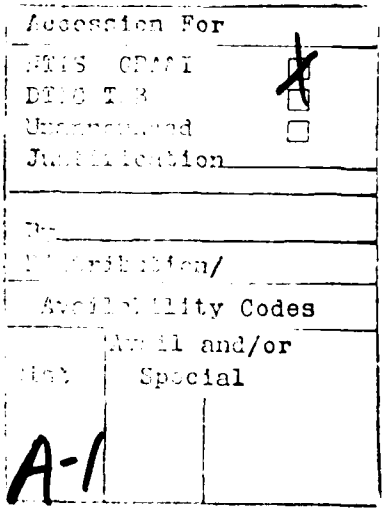

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INSTITUTE FOR DEFENSE ANALYSES

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PREFACE

This report was prepared by the Cost Analysis and Research Division of the Institute for Defense Analyses (IDA). The work was sponsored by IDA using central research funding. The report describes historical trends in direct and indirect costs at four defense aircraft contractors. The trends are not presented for each individual contractor, rather for the four contractors in aggregate. Due to the manner in which data were aggregated, the report contains no proprietary information.

Prior reports prepared by IDA on these same contractors, and many others, contain proprietary information and thus are not generally available. The purpose of this document is to provide to interested users a non-proprietary description of past cost experience for representative firms in the industry, along with an indication of what current trends portend for the future.

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FIGURES

TABLES

I. INTRODUCTION

This document presents trends in both direct and indirect costs for four firms in the defense airframe manufacturing industry. IDA has been studying the cost structure and behavior of these and other defense aerospace firms since 1981 as part of a series of task orders issued by the Office of the Assistant Secretary of Defense, Program Analysis and Evaluation (OASD(PA&E)). The objectives of the project were to:

- Increase understanding of defense contractor indirect costs
- Define trends in such costs and the factors that drive them
- Apply the findings to improve methods for estimating the costs to acquire defense weapon systems.

Data from the following defense contractors are included in this compilation:

- General Dynamics-Fort Worth Division [1]
- Grumman Aerospace Corporation [2]
- McDonnell Aircraft Company [3]
- Northrop Aircraft Company [4].

The combined data cover the years 1973-87, except for employment where only 1974-87 data are available.[1] Percentages derived are weighted rather than averages of percentages.

We present the data by cost element, e.g., Business Base, Employment, and Plantwide Overhead. Over the years, we developed standardized categories of indirect costs and of functions (groups of overhead pools by engineering, manufacturing, material. and general and administrative (G&A)). We worked closely with each firm when adjusting the data to conform as nearly as possible to standard definitions and to make the data comparable across firms.

Brief descriptions of the four aircraft contractors follow. (No proprietary data have been included in this study, so data on individual contractors are limited.)

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1 An earlier report (Reference [5]) describes similar trends over a shorter period, the years 1973-1982.

A. GENERAL DYNAMICS-FORT WORTH DIVISION (GD-FWD)

GD-FWD is a division of the General Dynamics Corporation headquartered in St. Louis, Missouri. The design and production facilities are primarily located at Air Force Plant No. 4 in Fort Worth, Texas, adjacent to Carswell Air Force Base whose runways are used by GD-FWD. The main factory building is about one mile in length and is one of the largest aircraft plants in the world. Operations at Air Force Plant No. 4 officially started on April 17, 1942.

The data base covers 1969-87, during which time the division's deliveries of F-111 fighter-bombers ended and employment reached new lows, followed by rapid recovery as the F-16 fighter production phased in and increased significantly. During this period GD-FWD was a "system integration house," which, as production levels increased, used external sources to produce volume parts and subassemblies that the Fort Worth plant integrated into final assemblies. Accordingly, the business base may be viewed as being composed of two components, in-plant costs and external costs. Reference [1] presents analyses of GD-FWD's trends and supporting information.

B. GRUMMAN AEROSPACE CORPORATION

Grumman Aerospace Corporation is a part of the Grumman Corporation of Bethpage, Long Island, New York. The primary facilities are located there and at nearby Calverton. Grumman began operations on January 2, 1930, with 21 employees. The data base covers 1973-87. Production of the F-14 Tomcat fighter for the Navy peaked in 1975, but production of the F-14 and other new aircraft was at a steady level until 1987. Other aircraft produced include the EA-6 Prowler electronic warfare aircraft, the E-2C Hawkeye airborne early warning (AEW) aircraft, and the C-2A Greyhound carrier on-board delivery aircraft. Grumman underwent a major reorganization on January 1, 1986, and 1986-87 data have not been adjusted to conform to the data from 1973-85. Reference [2] contains analyses of Grumman's trends and supporting detail.

C. MCDONNELL AIRCRAFT COMPANY (MCAIR)

MCAIR is a part of the McDonnell Douglas Corporation headquartered in St. Louis, Missouri. MCAIR's design and production facilities are located adjacent to the St. Louis airport whose runways are used by MCAIR. The data base covers 1969-87, during which time F-4 fighter production phased down and deliveries reached a new low in 1972. Subsequently, MCAIR switched to a multi-production situation with the addition of AV-8B

and F-18 production in addition to F-15 fighters. Like GD-FWD, MCAIR's business base during this period incorporated substantial production from other firms—from Northrop for F-18 subassemblies and from British Aerospace Corporation for AV-8B subassemblies. Accordingly, the business base may be viewed as being composed of two components, in-plant costs and external costs. Reference [3] contains analyses of MCAIR's trends and supporting detail.

D. NORTHROP AIRCRAFT DIVISION

Northrop Aircraft Division is a part of the Northrop Corporation headquartered in Los Angeles, California. Northrop's design and production facilities are located in Hawthorne and El Segundo, California, near the Los Angeles International Airport. The data base covers 1969-87 during which time production of the T-38 and F-5 series aircraft ended as production of F-18 Shipsets built up, as did parts for commercial aircraft, such as the 747 and 707. Development of the B-2 Advanced Technology Bomber took place until January 1, 1983, when the B-2 effort was transferred to the Advanced Systems Division. Reference [4] contains analyses of Northrop's trends and supporting detail.

II. TRENDS

In this section we present aggregated historical time-series data on the four aircraft contractors and identify trends within different categories of cost. The financial information on each contractor was first normalized and translated to 1987 dollars before being summed to arrive at the totals included in the tables presented here.

Table 1 presents a high-level summary of sales, cost, employment, and capital investment experience over the period 1973 to 1987. Both sales and business approximately doubled in size over this period. Sales rose to about $12 billion by 1987, and business followed to about $11 billion.

Table 1. Summary Statistics (Millions of 1987 Dollars)

	Sales	Total Business	In-Plant Business	Total Employment[a]	Plantwide Overhead	Direct Labor	Net Book Value
1973	6,494	6,065	n/a	n/a	2,085	1,245	644
1974	6,273	6,090	4,966	64,105	2,251	1,258	665
1975	6,678	6,305	5,016	61,287	2,288	1,217	694
1976	8,296	7,457	5,222	62,734	2,436	1,258	709
1977	9,181	8,123	5,159	62,465	2,517	1,259	731
1978	9,764	8,423	5,281	65,423	2,661	1,312	874
1979	8,882	8,311	5,446	68,172	2,774	1,351	975
1980	8,956	8,609	5,663	70,569	2,941	1,430	1,160
1981	9,389	8,953	6,099	74,411	3,140	1,514	1,347
1982	9,652	9,386	6,603	78,017	3,331	1,563	1,662
1983	10,232	9,552	6,393	76,788	3,271	1,534	1,493
1984	10,344	9,420	6,407	75,971	3,441	1,538	1,648
1985	11,858	10,369	6,990	80,422	3,693	1,681	1,850
1986	12,431	10,898	7,444	81,691	3,753	1,811	2,081
1987	12,333	11,192	7,551	83,400	3,708	1,897	2,206

Note: n/a means data were not available.

[a] Employment is measured in manyears or headcount, depending on the firm.

We differentiate between total business and "in-plant" business to present a clearer view of activities and relationships between cost elements at a specific location. In the cases of MCAIR and GD-FWD, for example, included in their business totals are very

large efforts that were performed outside the plants of interest and therefore were not supported by the overhead costs at those locations. These included the European effort associated with coproduction of the F-16, and the Northrop portion of the F-18 effort. When considering trends by cost element, it is more informative to compare in-plant business to other cost elements associated with the particular facility, such as overhead and capital investments. Table 1 shows that while business nearly doubled over the period, in-plant business increased by only about 50 percent. This indicates the extent of the distortion that might result from using business base in our comparisons.

Over the same period when in-plant business was increasing by 50 percent (between 1974 and 1987), plantwide overhead increased about 65 percent and employment increased by only 30 percent. Over the same period, the net book value of these firms increased by nearly 350 percent. The trends in these cost components reflect the evolution in manufacturing whereby capital was being substituted for labor.

The remainder of this section presents more detailed discussions of the costs and trends in the cost elements listed in Table 1, starting with in-plant business. Neither sales nor total business is discussed further.

A. IN-PLANT BUSINESS

Table 2 displays a disaggregation of in-plant business that shows the costs associated with the different categories of labor along with the costs of materials and overhead.[2] These categories are plotted as percentages of in-plant business in Figure 1. Also shown in the figure are linear trend lines derived using least squares methods.

Overhead costs trended upward from 43 percent to more than 50 percent of in-plant business during this period. Materials costs declined, and while total direct labor remained about level, the mix of direct labor shifted. Manufacturing labor declined from 14 percent of in-plant business to about 11 percent.

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2 Plantwide overhead in Table 2 is less than the totals shown in Table 1 because in Table 2 the direct labor and direct material for independent research and development/bid and proposal (IR&D/B&P) expense are included in direct labor and direct material, respectively. IR&D/B&P is initially a direct charge and the labor is "burdened." Subsequently, IR&D/B&P is transferred to general and administrative expense for cost-recovery purposes. For this study, we did not wish to pick up the overhead or burden added to IR&D/B&P, so we eliminated this duplicate burden (it was originally recorded in the various overhead pools, so we have already captured it). The reader may find slight discrepancies in the 1974-86 years due to the application of different price indices to adjust the data to constant 1987 dollars.

Table 2. In-Plant Business
(Millions of 1987 Dollars)

	Engineering Direct Labor	Manufacturing Direct Labor	Other Direct Labor	Total Direct Labor	Direct Material	Plantwide Overhead	Total Business
1974	552	696	10	1,258	1,576	2,132	4,966
1975	529	654	35	1,217	1,625	2,174	5,016
1976	552	658	48	1,258	1,643	2,320	5,222
1977	573	619	67	1,259	1,514	2,386	5,159
1978	583	655	74	1,312	1,455	2,514	5,281
1979	596	654	102	1,351	1,482	2,612	5,446
1980	628	681	121	1,430	1,461	2,772	5,663
1981	644	741	129	1,514	1,627	2,958	6,099
1982	671	766	127	1,563	1,882	3,158	6,603
1983	662	723	150	1,534	1,775	3,084	6,393
1984	684	689	165	1,538	1,633	3,236	6,407
1985	763	736	181	1,681	1,846	3,463	6,990
1986	787	797	227	1,811	2,123	3,510	7,444
1987	793	811	293	1,897	2,145	3,509	7,551

Note: Totals may not add across due to rounding.

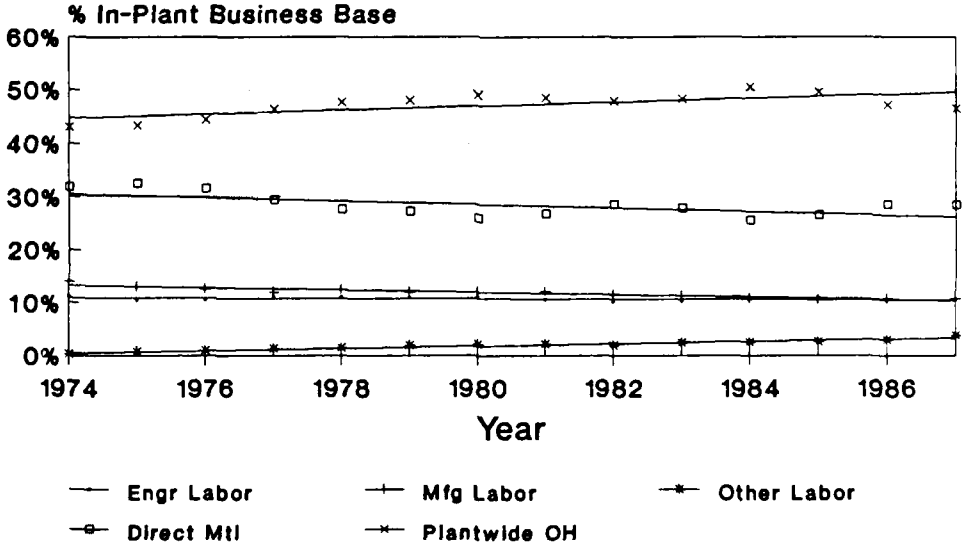

Figure 1. Business Trends

B. EMPLOYMENT

Employment data shown in Table 3 contain systematic errors due to a data consistency problem. The numbers in the table are sums across four contractors, three of which provided us with average manyears, and the other headcount. In this regard, the totals, in absolute terms, are not accurate. However, we believe this inconsistency does not significantly distort trends over this extended period. Figure 2 contains plots of these data along with linear trend lines.

Table 3. Average Employment by Function (Average Man Years or Headcount)

	Engineering	Manufacturing	Material	G&A	Other	Total
1974	19,033	33,273	3,080	5,463	3,256	64,105
1975	18,596	31,175	3,080	5,398	3,038	61,287
1976	19,001	31,820	3,252	5,448	3,213	62,734
1977	19,603	30,411	3,470	5,500	3,481	62,465
1978	20,255	32,143	3,639	5,631	3,755	65,423
1979	21,050	33,136	3,974	5,909	4,103	68,172
1980	21,979	33,981	4,192	6,212	4,205	70,569
1981	22,772	36,282	4,201	6,485	4,671	74,411
1982	23,886	37,931	4,263	6,656	5,281	78,017
1983	23,824	37,286	4,138	6,404	5,136	76,788
1984	24,356	35,866	4,048	6,541	5,160	75,971
1985	26,492	37,695	4,092	6,663	5,480	80,422
1986	27,312	39,803	3,733	5,163	5,680	81,691
1987	27,570	41,043	3,705	4,890	6,192	83,400

The most noteworthy trends are a decrease in manufacturing, from 52 to 49 percent of total employment, and an increase in engineering, from 30 to 33 percent. Over the same period G&A-related employment declined by nearly one-third, going from about 9 percent to about 6 percent. The other employment categories represent small proportions and show little variation.

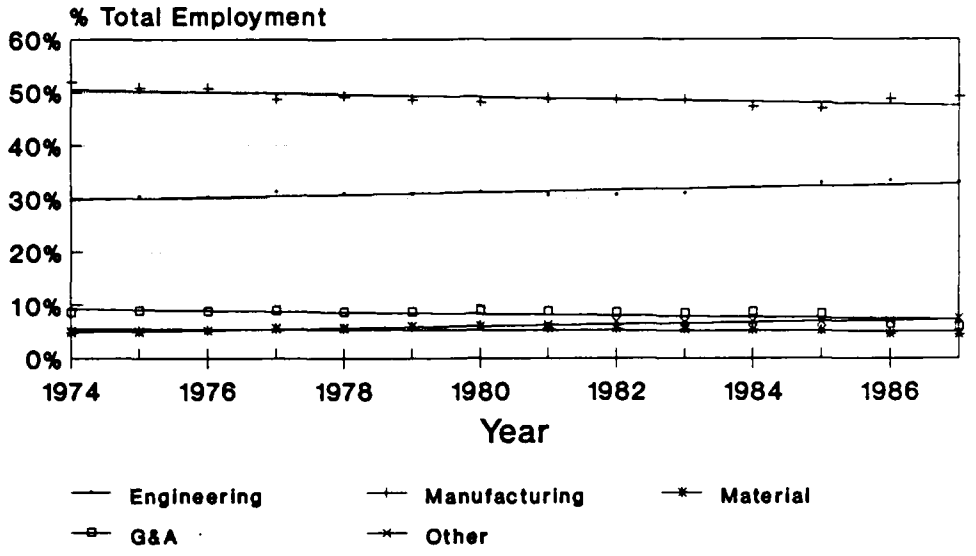

Figure 2. Employment Trends

C. CAPITAL

Aggregate capital data for the four contractors are included in Table 4. Capital investments rose from about $87 million in 1973 to more than $436 million by 1986, representing a five-fold increase. Net book value rose by more than a factor of three, as did depreciation, both driven by the sharp increases in capital investments.

Direct labor dollars are also included in Table 4 to allow comparison with net book value. Direct labor increased from about $1.2 billion to about $1.9 billion over the period, essentially paralleling the 50-percent increase in in-plant business. Over the same period, net book value increased much faster, as indicated by its ratio with direct labor dollars. The two measures (net book value, direct labor dollars) are plotted in Figure 3, along with the ratio of the two. The ratio, growing from about .5 to about 1.2, indicates a sustained practice of substitution of capital for labor.

Table 4. Labor and Capital Data (Millions of 1987 Dollars)

	Capital Investment	Net Book Value	Depreciation	Direct Labor	Ratio of NBV to Direct Labor
1973	87	644	78	1,245	0.518
1974	87	665	73	1,258	0.528
1975	83	694	72	1,217	0.570
1976	70	709	70	1,258	0.563
1977	73	731	67	1,259	0.580
1978	158	874	64	1,312	0.666
1979	149	975	73	1,351	0.721
1980	225	1,160	83	1,430	0.811
1981	237	1,347	98	1,514	0.890
1982	403	1,662	123	1,563	1.063
1983	200	1,493	140	1,534	0.973
1984	286	1,648	151	1,538	1.072
1985	349	1,850	173	1,681	1.101
1986	436	2,081	200	1,811	1.149
1987	363	2,206	234	1,897	1.163

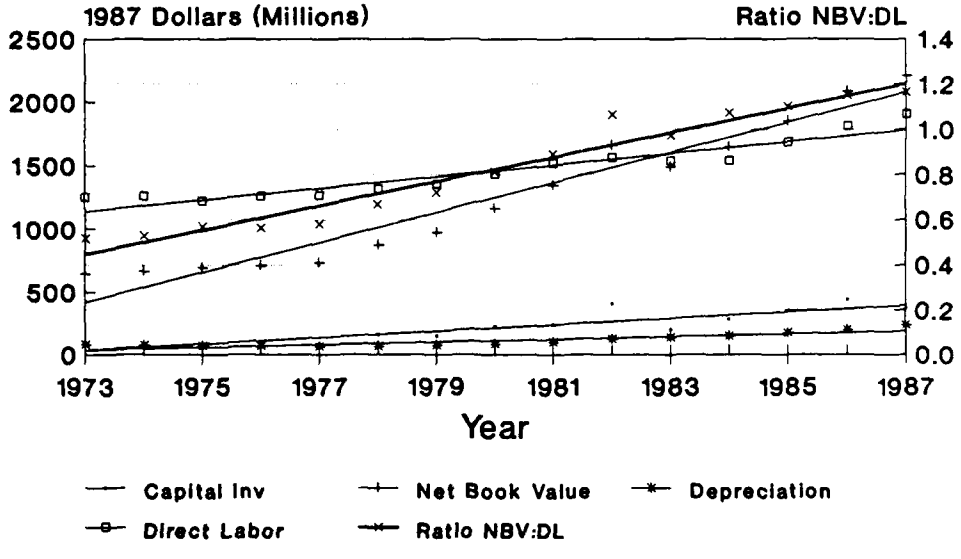

Figure 3. Labor and Capital Trends

D. PLANTWIDE OVERHEAD

In this subsection we present two broad views of trends in plantwide overhead. The first view is by function (e.g., engineering, manufacturing), and the second by account group (e.g., indirect labor, fringe benefits).

1. Functions

During the course of our earlier studies [References 1, 2, 3, and 4], we translated all primary overhead pools into four groups representing the functions of engineering, manufacturing, material, and general and administrative (G&A) expenses. Aggregate data for these categories are included in Table 5 and plotted, along with linear trend lines, in Figure 4.

Table 5. Overhead by Function (Millions of 1987 Dollars)

	Engineering	Manufacturing	Material	G&A	Total
1973	517	870	166	532	2,085
1974	546	971	174	561	2,251
1975	550	970	176	591	2,288
1976	600	1,025	191	620	2,436
1977	626	1,011	197	683	2,517
1978	663	1,065	215	718	2,661
1979	692	1,116	234	732	2,774
1980	745	1,169	252	775	2,941
1981	786	1,284	262	808	3,140
1982	870	1,376	271	815	3,331
1983	833	1,336	259	842	3,271
1984	874	1,339	272	956	3,441
1985	953	1,433	279	1,028	3,693
1986	1,037	1,483	294	940	3,753
1987	1,060	1,518	281	849	3,708

Note: Totals may not add across due to rounding.

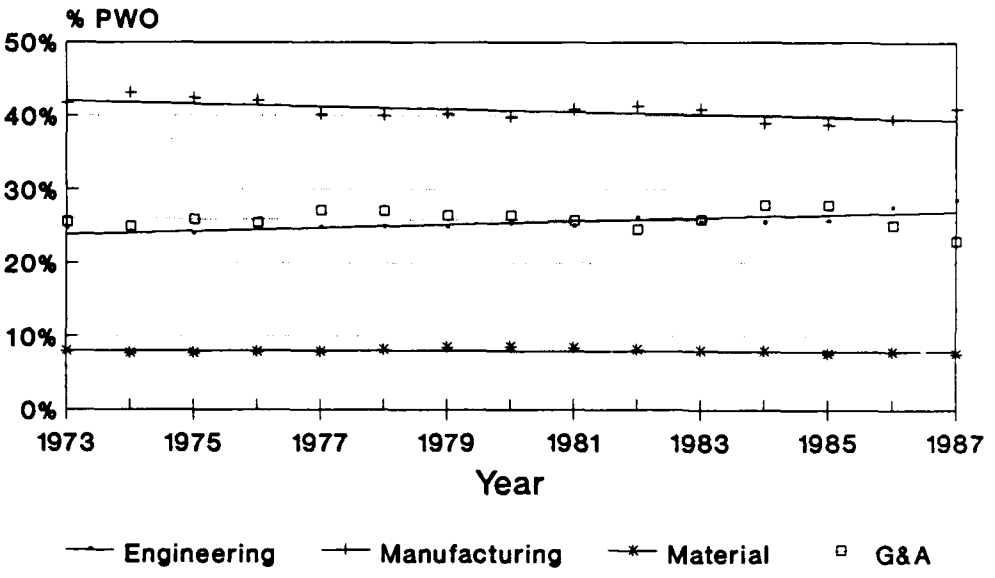

Figure 4. Overhead by Function Trends

This period saw engineering overhead increase from about 24 percent of plantwide overhead to about 29 percent as manufacturing processes became more capital intensive. At the same time, G&A dropped from about 26 percent to under 23 percent by 1987 as some of these firms reorganized and took steps to reduce overhead in the 1986-87 period. Manufacturing overhead deviated little from 41 percent, showing only a slightly declining trend over the period. Material overhead remained essentially unchanged.

2. Account Groups

Data from each of the firms were adjusted to conform to the account groups listed in Table 6. The adjusted data and their trend lines are graphed in Figure 5. These representations give a clearer picture of what transpired during these years. Facilities-related costs increased sharply from 12 to 17 percent, reflecting large capital investments made to install modern manufacturing equipment, particularly in the area of fabrication. Data processing costs also rose sharply, from 6 to about 11 percent, reflecting the increased use and importance of computers in manufacturing. These increases forced proportional declines in both indirect labor and fringe benefits, from about 32 percent down to about 25 percent.

Table 6. Plantwide Overhead by Account Group (Millions of 1987 Dollars)

	Indirect Labor	Fringe Benefits	Facilities-Related	Data Processing	Corporate Office Allocation	IR&D/ B&P	Other Expenses	Secondary Allocations	Credits	Total
1973	679	677	243	124	81	111	244	-51	-22	2,085
1974	700	745	265	143	78	120	260	-40	-19	2,251
1975	665	770	291	154	94	115	250	-29	-23	2,288
1976	708	854	300	167	99	117	251	-14	-46	2,436
1977	715	865	324	191	110	132	246	-19	-46	2,517
1978	761	890	331	215	122	148	272	-25	-52	2,661
1979	793	903	341	228	124	163	308	-28	-58	2,774
1980	822	944	379	255	121	171	349	-32	-69	2,941
1981	862	986	423	272	124	185	384	-27	-70	3,140
1982	907	1,064	450	284	141	174	395	-32	-52	3,331
1983	865	1,028	467	300	147	188	379	-55	-47	3,271
1984	886	1,020	524	330	174	206	414	-67	-47	3,441
1985	930	1,062	594	374	170	231	448	-74	-44	3,693
1986	886	998	572	393	176	244	419	113	-49	3,753
1987	926	969	611	397	163	199	412	95	-63	3,708

Note: Totals may not add across due to rounding.

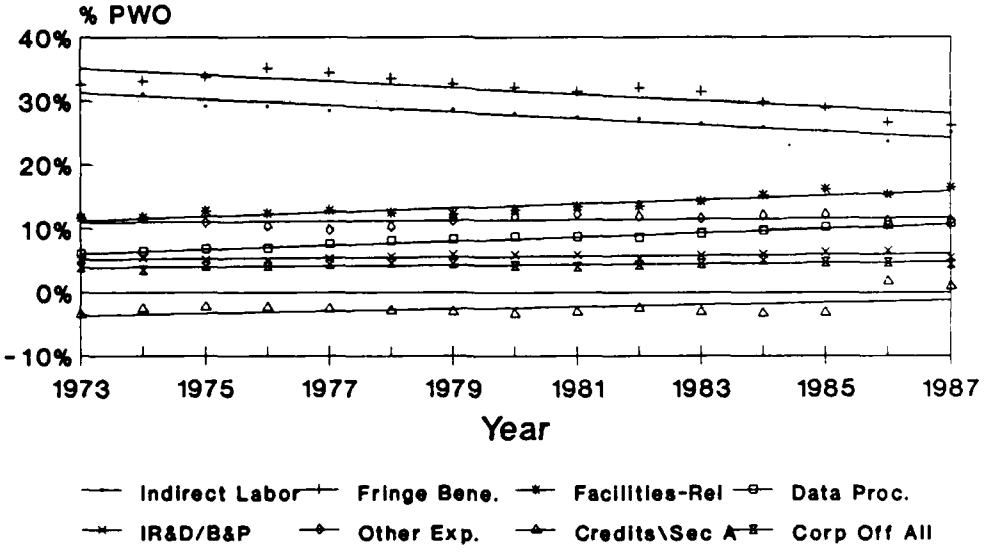

Figure 5. Plantwide Overhead Trends

III. EXTRAPOLATION OF TRENDS

In this section we extrapolate historical and current trends into the future and then discuss the implications for defense cost analysts.

A. EXTRAPOLATION

Identifying historical cost trends is useful as an aid in understanding what occurred in the past. But, more importantly, these data and trends can provide an indication of what we might observe in the future if current trends persist.

For curiosity sake, we made simple extrapolations of the data out to the year 2020. The procedure used was to extend the regression lines shown in the figures. The results associated with several high-level elements are summarized in Table 7. Again, we stress that these findings are not forecasts, but rather implications of trends.

Table 7. Extrapolation of Trends to 2020

	Percent of In-Plant Business		
	1974	1987	2020
Direct Labor			
Manufacturing	14	10	3
Engineering-Related[a]	11	14	20
Direct Material	32	26	15
Plantwide Overhead	43	50	62

[a] Engineering-related includes both engineering and other direct costs.

Direct manufacturing labor decreased steadily as the aircraft airframe contractors in our sample moved away from labor-intensive fabrication and assembly procedures. The introduction of computer-aided design and manufacturing, numerically controlled machines, and other labor-replacing devices resulted in a drop from 14 percent of in-plant business in 1974 to about 10 percent by 1987. If this trend continues, manufacturing will account for only about 3 percent of direct labor at these contractors by the year 2020. These findings are plausible when viewed in light of current experience at aircraft engine

and electronics manufacturers. Direct manufacturing labor at samples of these firms show percentages in the range of 3 to 6 percent at the current time.

Engineering effort is moving in the opposite direction. Replacing manufacturing workers with machines in the production of advanced technology weapon systems involves engineering, and a lot of it. This sort of effort has been on the rise over the past two decades and likely will continue this trend for some time. If current trends continue, manufacturing will be accomplished by machines while almost all direct labor will be engineering-related by some time early in the next century.

Plantwide overhead increased to represent about 50 percent of in-plant business by 1987. This rise was related to the substitution of capital for labor discussed earlier. Facilities-related expenses and data processing costs moved upward as manufacturing labor declined. Both of these trends were the results of extensive factory modernization efforts of the eighties. If these trends and current methods of accounting continue, plantwide overhead will grow to represent about 62 percent of in-plant business by 2020.

The decline in materials, as a percent of in-plant business, seems to be as much the result of increases in overhead costs as gained efficiencies in the materials area. These two factors contributed to a decline from about 32 percent to about 26 percent between 1974 and 1987. If this trend continues, materials will represent about 15 percent of in-plant business by 2020.

While not shown in the table, we also extrapolated the capital-labor ratio. This ratio had risen from about .5 to about 1.2 between 1974 and 1987, once again reflecting the substitution of capital for labor over the period. If current trends continue in the numerator and denominator, the ratio will be about 1.8 by the year 2020.

B. IMPLICATIONS

Defense cost analysts use past cost experience on similar systems as a guide for projecting the costs of future systems. To support their work, these cost analysts have been collecting cost experience on the development and production of defense systems for decades. Separate data bases exist for aircraft (both fixed- and rotary-winged), missiles, ships, land vehicles, electronics/avionics, and so on.

The practice of collecting and archiving these data became prevalent sometime after the World War II, during a period when direct labor was clearly the most important cost driver. Data collection formats focused on this cost element. Cost estimating methods that dealt with these costs came into common practice. An example is the learning curve that

models the reduction in time required to perform a task as it is performed over and over again. These labor-based methods evolved over the decades from being novel to traditional. Overhead costs were neither visible nor understood, so common practice was to use poorly documented (sometimes proprietary) factors to "burden" the labor estimates. The practice has persisted, even though direct manufacturing labor has nearly disappeared as a cost driver, and overhead has grown to represent more than half the cost of defense systems, and may rise to represent two-thirds of these costs. Even today, when building an estimate for a future weapon system, cost analysts continue to begin the process with cornerstones representing the labor hours required for each major component. Our findings, reported above, indicate that both the data and methods of cost estimating and analysis need to be jerked free of their sedentary state and realigned with what is really happening on the modern factory floor.

The trends we see in cost components tell us that defense cost data bases that are chocked full of labor hours, are becoming of less and less value. This, in and of itself, would not be worrisome if initiatives were being taken to identify the new cost drivers, establish collection systems and conduct research to relate these new drivers to costs in a manner that would be useful for forecasting purposes.

We believe the DoD should reconsider the high investment it continues to make in perpetuating cost data bases that support the development of estimating relationships for labor hours, which are declining to represent but a few percent of total costs. Further, we believe these investments would be better spent on increasing the visibility and understanding of overhead costs, which represent half to two-thirds the cost of weapon systems. Also, research should be initiated to identify drivers of direct costs that are replacing labor. Data collection efforts should be redirected to these items, as should efforts to develop improved cost estimating methods.

REFERENCES

[1] McCullough, James D., James K. Bui, and Thomas P. Frazier. "Defense Contractor Indirect Costs: General Dynamics–Fort Worth Division, 1969-87." Paper P-2244, Institute for Defense Analyses, August 1989.

[2] McCullough, James D., and Rosemary H. Jones. "Defense Contractor Indirect Costs: Grumman Aerospace Corporation, Grumman Corporation 1983-87." Paper P-2280, Institute for Defense Analyses, August 1989.

[3] McCullough, James D., James K. Bui, and Thomas P. Frazier. "Defense Contractor Indirect Costs: McDonnell Aircraft Company, 1969-87." Paper P-2179, Institute for Defense Analyses, August 1989.

[4] McCullough, James D., James K. Bui, and Thomas P. Frazier. "Defense Contractor Indirect Costs: Northrop Aircraft Division, 1969-87." Paper P-2190, Institute for Defense Analyses, August 1989.

[5] McCullough, James D., and Stephen J. Balut. "Defense Contractor Indirect Costs: Trends, 1973-82." Paper P-1909, Institute for Defense Analyses, March 1986.